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THE KNOCK-LIMITED PERFORMANCE OF SEVERAL MISCELLANEOUS FUELS BLENDED WITH A BASE FUEL

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ADVANCE CONFIDENTIAL REPORT

THE KNOCK-LIMITED PERFORMANCE OF SEVERAL MISCELLANEOUS FUELS BLENDED WITH A BASE FUEL

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SUMMARY

Investigations were conducted to determine the knock-limited performance of blends of 90 percent by volume AN-F-28, Amendment-2, fuel and 10 percent by volume of each of the following fuels: tert-amyl alcohol, 2,6-dimethyl-1,4-dioxane, methyl tert-butyl ether, methyl tert-butyl ketone, methyl isobutyl ketone, mesityl oxide, acetone, and diisopropyl ketone. The investigations were conducted in a supercharged CFR engine with an inlet-air temperature of 250° F, an engine speed of 2500 rpm, a compression ratio of 7.0, and a spark advance of 30° B.T.C.

The data indicated that only the addition of methyl tert-butyl ether or methyl tert-butyl ketone to AN-F-28 fuel resulted in a significant increase in the knock-limited power. Methyl tert-butyl ether gave a greater increase than did methyl tert-butyl ketone.

INTRODUCTION

The tests presented in this report, which are of a preliminary nature, were run on several exploratory fuels, many of which were available only in small quantities. The fuel blend containing methyl tert-butyl ketone was prepared by the Fuel Synthesis Section of this laboratory; the rest were commercially obtained. Several of these fuels have been tested by other laboratories. (See reference 1, pp. 239, 240, and 265.)

Each fuel was tested as a 10 percent by volume blend with AN-F-28, Amendment-2, fuel. The knock-limited performance of the blend was then compared with the knock-limited performance of AN-F-28 fuel. Data covering the entire range of fuel-air ratios were obtained on less than a quart of exploratory fuel.

This investigation was conducted at the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics during the latter part of 1943.

APPARATUS AND TEST PROCEDURE

All tests were run on a high-speed supercharged CFR engine equipped with an aluminum piston and a cylinder with four spark-plug holes. Knock was detected by a cathode-ray oscilloscope that was connected to a magnetostriction pickup unit. Two spark plugs were simultaneously operated from separate spark coils.

The following exploratory fuels were tested: *tert*-amyl alcohol, 2,6-dimethyl-1,4-dioxane, methyl *tert*-butyl ether, methyl *tert*-butyl ketone, methyl isobutyl ketone, mesityl oxide, acetone, and diisopropyl ketone.

All data taken were knock-limited and each test was carried very close to the combustion limit in both the lean and the rich regions. The following engine conditions were maintained constant:

Engine speed, rpm	2500
Inlet-air temperature, °F	250
Outlet-coolant temperature, °F	250
Oil temperature, °F	150
Compression ratio	7.0
Spark advance, deg B.T.C.	30

Tests were run on blends of 10 percent exploratory fuel and 90 percent AN-F-28 fuel by volume. Each of the tests of AN-F-28 fuel was made on the same day as the exploratory blend with which it was compared.

RESULTS AND DISCUSSION

The knock-limited indicated mean effective pressure and the indicated specific fuel consumption of each of the fuel blends and their respective reference fuel (AN-F-28) are plotted against the fuel-air ratio in figure 1. In the comparisons of the knock-limited performance of the various blends with that of AN-F-28 fuel, it should be remembered that the tetraethyl-lead concentrations are lower in the blends than in the original fuel.

The fuels in figures 1(a) and 1(b) were tested on three different days, and AN-F-28 reference fuel was tested on each of these days. The three reference curves were so similar that only one curve was drawn through the three sets of points. This combined curve is used on both figures. The fuels in figure 1(c) were not tested until about a month later and, in the meantime, other tests were run on the engine; consequently, the reference curve for this figure is different from the one on figures 1(a) and 1(b).

The power outputs obtained with the various blends and the power output obtained from AN-F-28 fuel alone are compared in table I. The blends containing methyl *tert*-butyl ether and methyl *tert*-butyl ketone gave average increases in knock-limited power over AN-F-28 fuel of about 20 percent and 7 percent, respectively. Methyl isobutyl ketone increased the knock-limited power in the lean region and decreased it in the rich region. *tert*-Amyl alcohol, mesityl oxide, and 2,6-dimethyl-1,4-dioxane caused a decrease in the knock-limited power, whereas acetone and diisopropyl ketone caused little change.

No significant difference was apparent between the rich-mixture indicated specific fuel consumption of any of the fuel blends and that of pure AN-F-28 fuel. Increases in the indicated specific fuel consumption were observed in the very lean region for most of the blends.

CONCLUSIONS

The following conclusions can be drawn from tests of fuel blends investigated:

1. The addition of methyl *tert*-butyl ether or methyl *tert*-butyl ketone to AN-F-28 fuel increased the knock-limited power at fuel-air ratios between 0.04 and 0.13. This increase in power is greater for the addition of methyl *tert*-butyl ether than for the addition of methyl *tert*-butyl ketone.

2. None of the fuels tested caused any significant changes in the indicated specific fuel consumption in the rich region. Changes were observed in the indicated specific fuel consumption in the lean region in some cases.

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REFERENCE

1. Egloff, Gustav, Hubner, W. H., and Van Arsdell, P. M.: Fuels for Internal-Combustion Engines. Chem. Rev., vol. 22, no. 1, Feb. 1938, pp. 175-280.

TABLE I. - THE RELATIVE POWER OUTPUTS OBTAINED WITH SEVERAL EXPLORATORY-FUEL BLENDS AS COMPARED WITH AN-F-28 FUEL

[CFR engine; compression ratio, 7.0; inlet-air temperature, 250° F; outlet-coolant temperature, 250° F; spark advance, 30° B.T.C.; engine speed, 250 rpm]

Fuel[a] (90 percent AN-F-28 fuel plus 10 percent of the following components:)	Relative power ratio = imep (exploratory-fuel blend) / imep (AN-F-28 fuel)			
	Fuel-air ratio			
	0.062	0.07	0.09	0.11
AN-F-28 fuel	1.00	1.00	1.00	1.00
tert-Amyl alcohol	.99	.92	.95	.95
2,6-dimethyl-1,4-dioxane	.94	.84	.86	.91
Methyl *tert*-butyl ether	1.25	1.26	1.14	1.20
Methyl *tert*-butyl ketone	1.15	1.08	1.02	1.05
Methyl isobutyl ketone	1.10	1.02	.95	.97
Mesityl oxide	.96	.87	.82	.90
Acetone	1.04	.95	1.00	1.02
Diisopropyl ketone	1.02	.89	.97	1.01

[a]The TEL content of AN-F-28 fuel was 4.55 ml/gal. The TEL content of the blends was 4.09 ml/gal.

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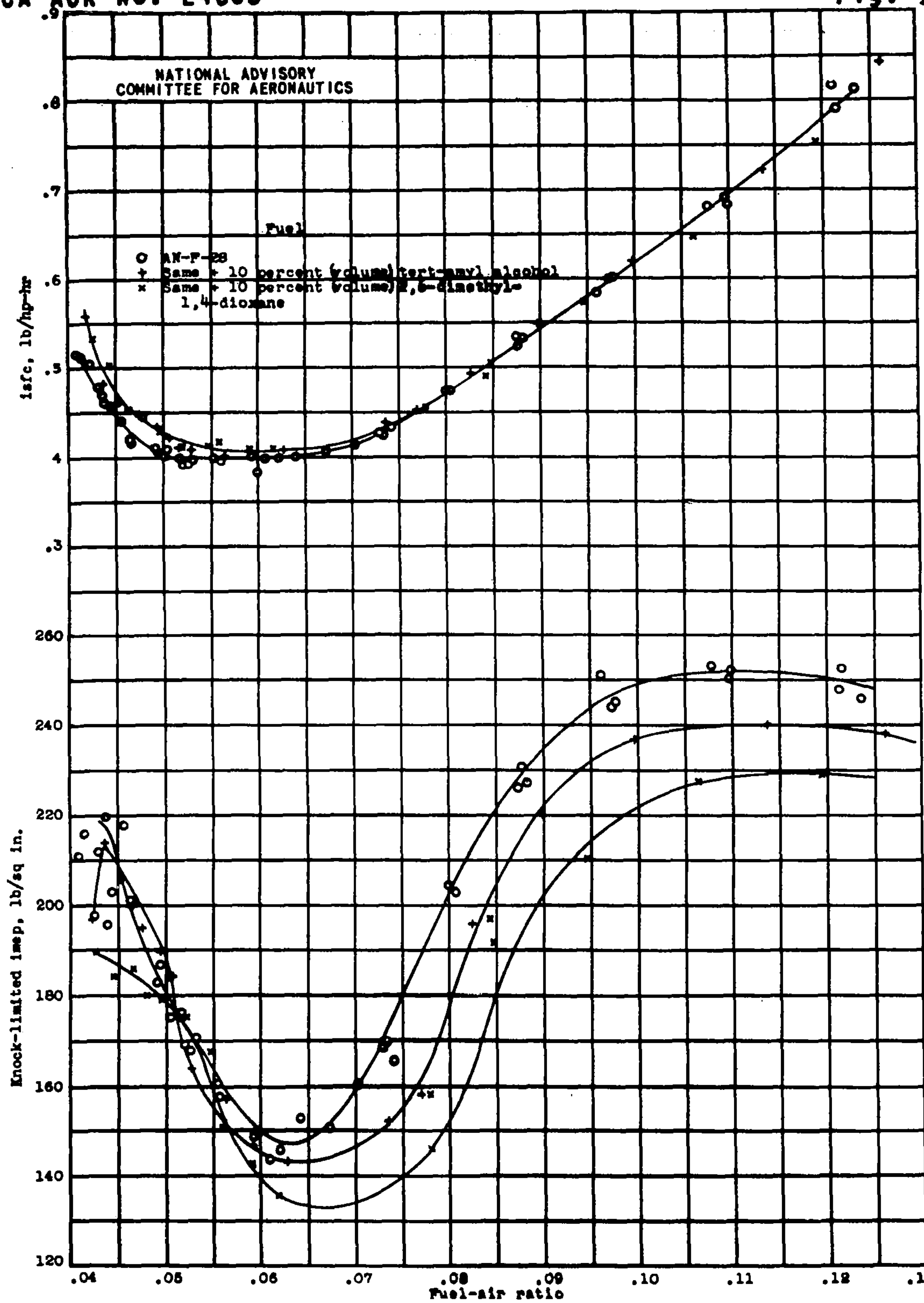
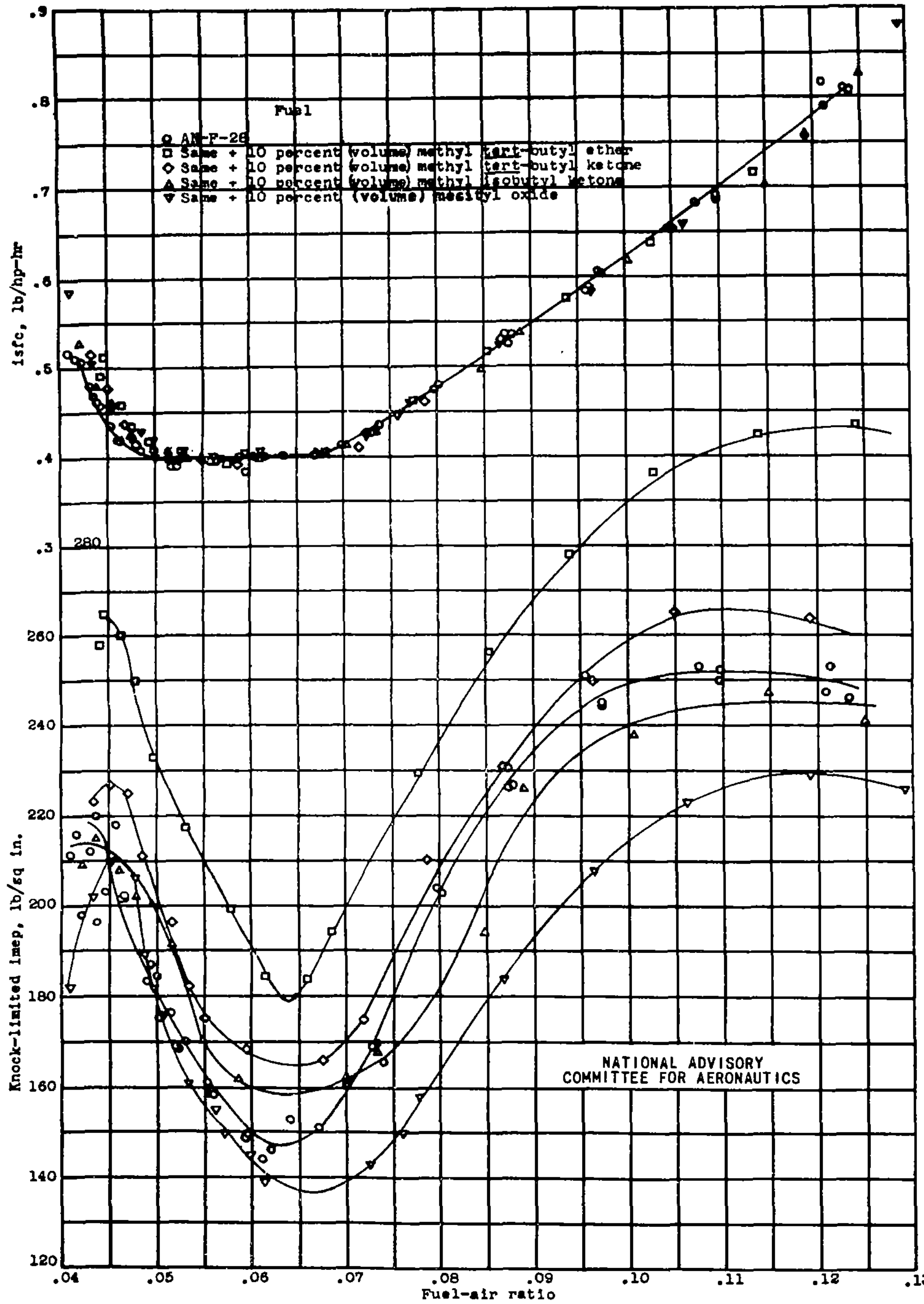
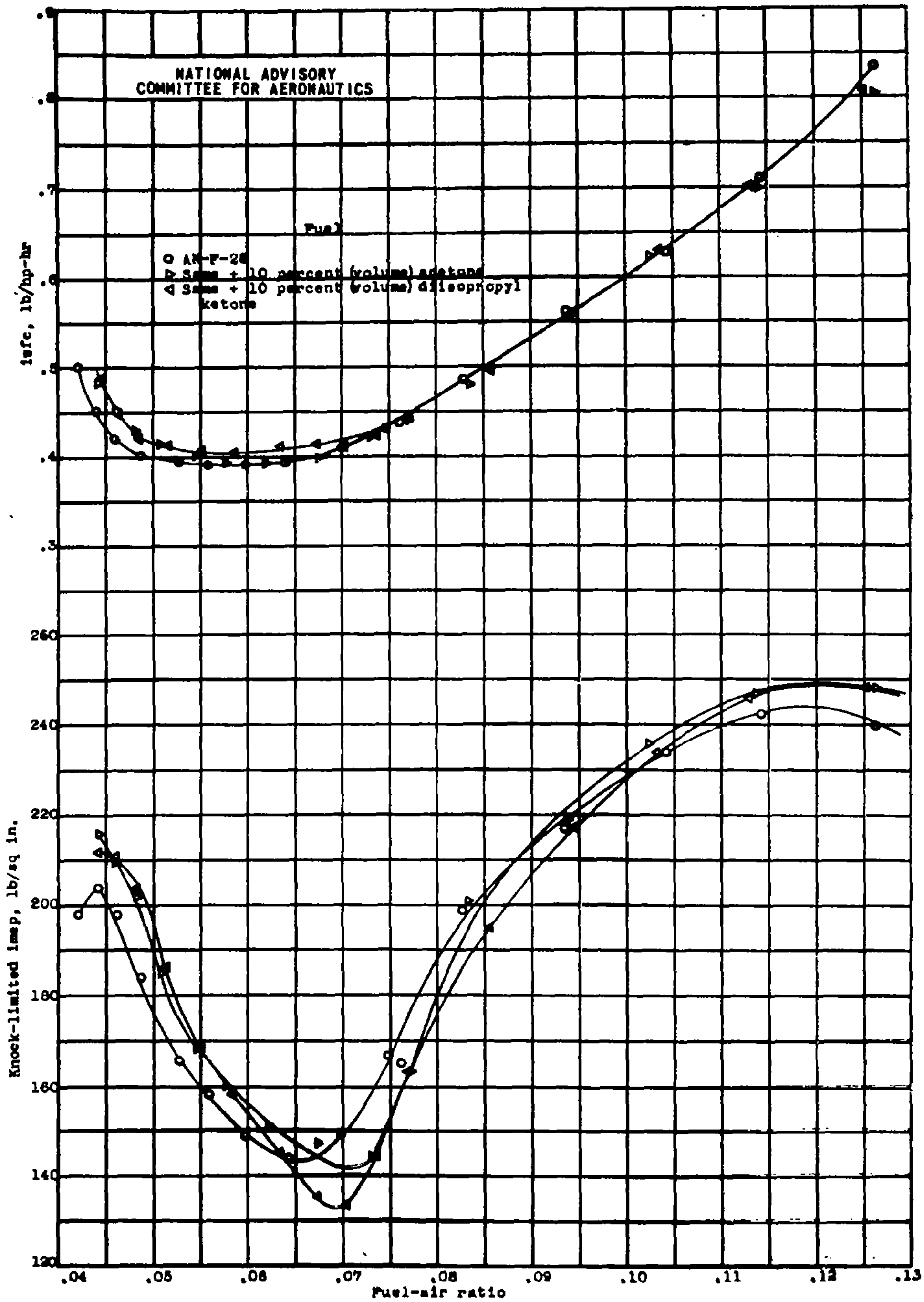


(a) Exploratory fuels: tert-amyl alcohol and 2,6-dimethyl-1,4-dioxane.
Figure 1. - Knock-limited performance of blends of 90 percent AN-F-28 fuel and 10 percent exploratory fuel. CFR engine; compression ratio, 7.0; outlet-coolant temperature, 250° F; inlet-air temperature, 250° F; spark advance, 30° B.T.C.; engine speed, 2500 rpm.



(b) Exploratory fuels: methyl tert-butyl ether, methyl tert-butyl ketone, methyl isobutyl ketone, and mesityl oxide.

Figure 1. - Continued. Knock-limited performance of blends of 90 percent AN-F-28 fuel and 10 percent exploratory fuel. CFR engine; compression ratio, 7.0; outlet-coolant temperature, 250° F; inlet-air temperature, 250° F; spark advance, 30° B.T.C.; engine speed, 2500 rpm.



(c) Exploratory fuels: acetone and diisopropyl ketone.
Figure 1. - Concluded. Knock-limited performance of blends of 90 percent AN-F-28 fuel and 10 percent exploratory fuel. CFR engine; compression ratio, 7.0; outlet-coolant temperature, 250° F; inlet-air temperature, 250° F; spark advance, 30° B.T.C.; engine speed, 2500 rpm.